Supplementary Information (SI) for Nanoscale.
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Supporting information

Ultrasound-driven triphasic contact-electro-catalytic CO_2 reduction to methanol

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Supplementary Figures

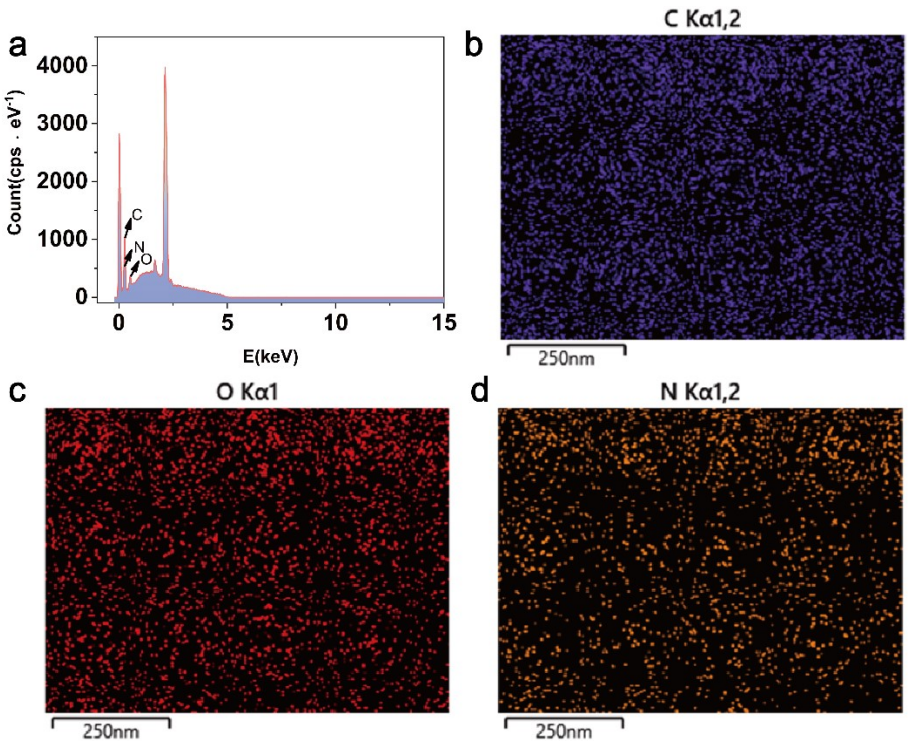

Figure S1. (a) EDS spectrum of PI aerogel under high-magnification microscopy (130,000×) and elemental distribution maps of C (b), O (c)and N (d).

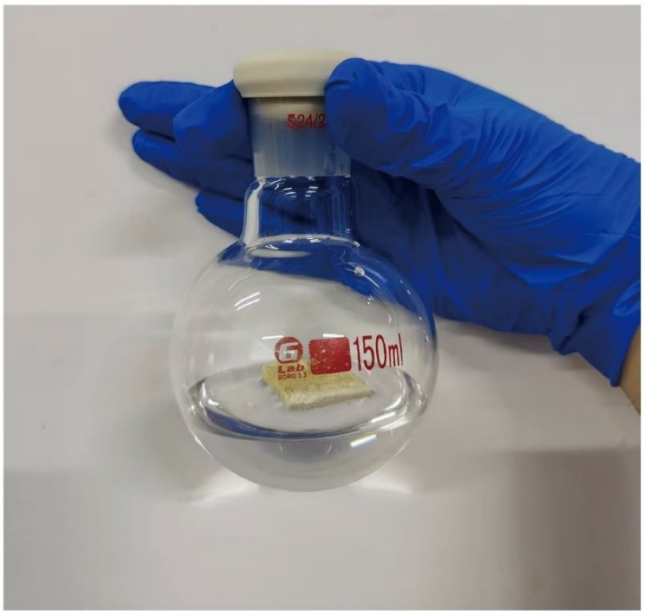

Figure S2. Photograph of holding the reaction vessel.

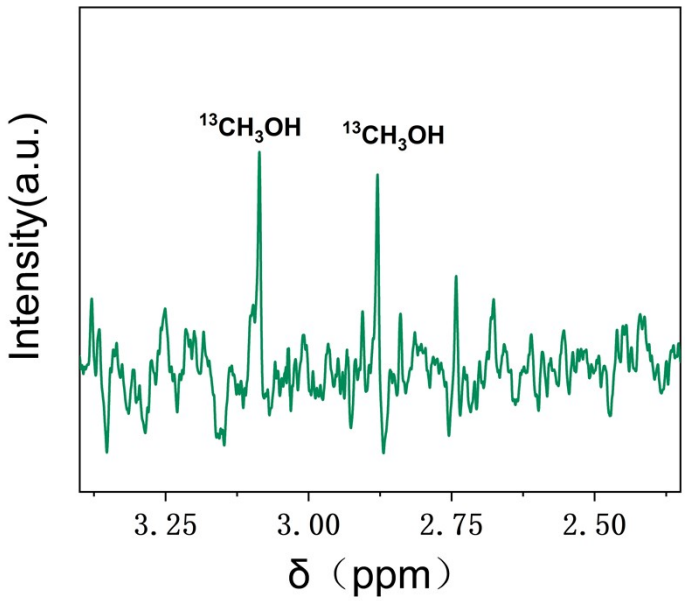

Figure S3. ^{1}H-NMR methanol peak obtained from experiments using ^{13}C-labeled CO_2

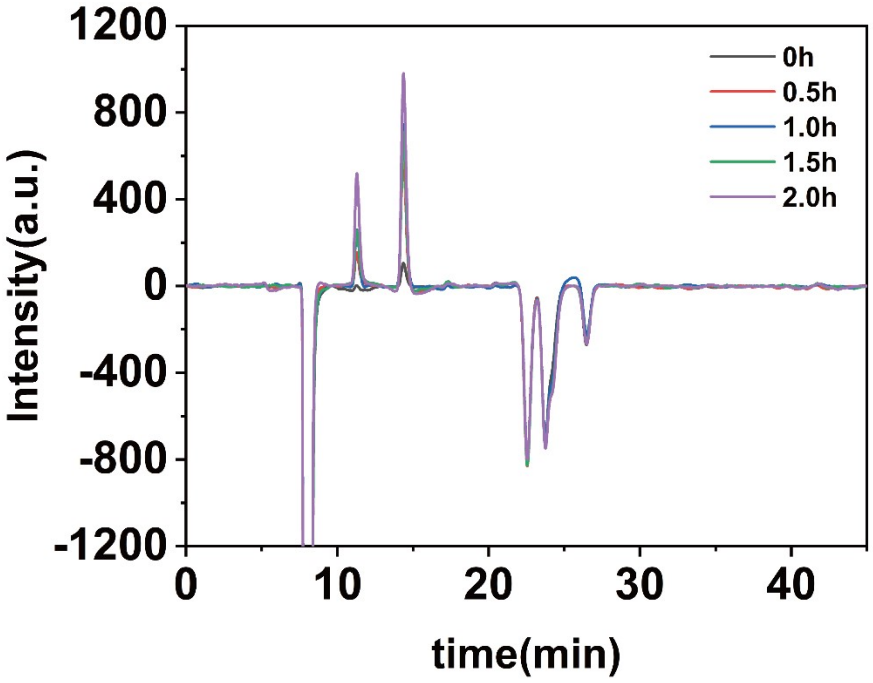

Figure S4. High-Resolution High-Performance Liquid Chromatography (HR-HPLC) of post-reaction liquid at 0-2 h.

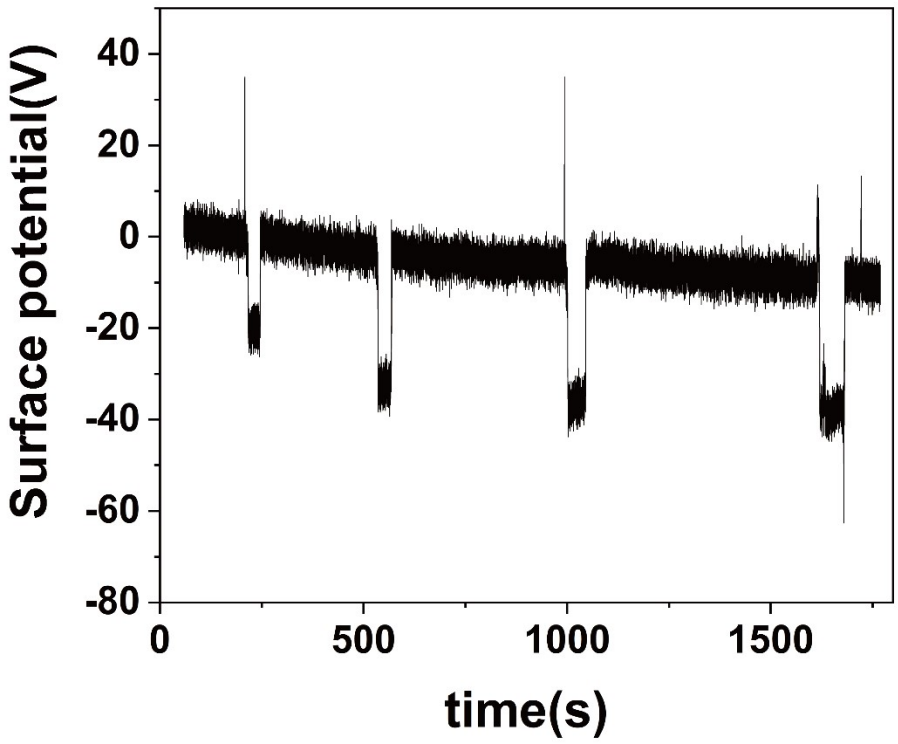

Figure S5. Graph of PI aerogel surface potential variation with ultrasound time

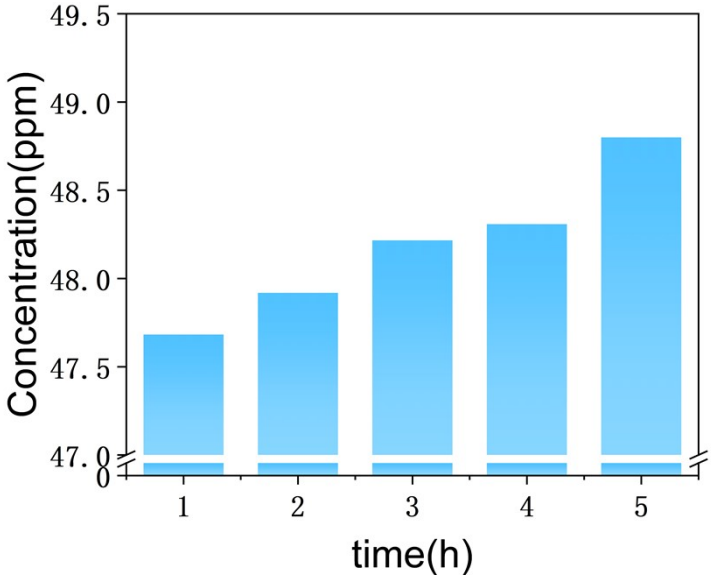

Figure S6. Bar chart of methanol concentration determined by HPLC using polyimide aerogel under 5h ultrasonication.

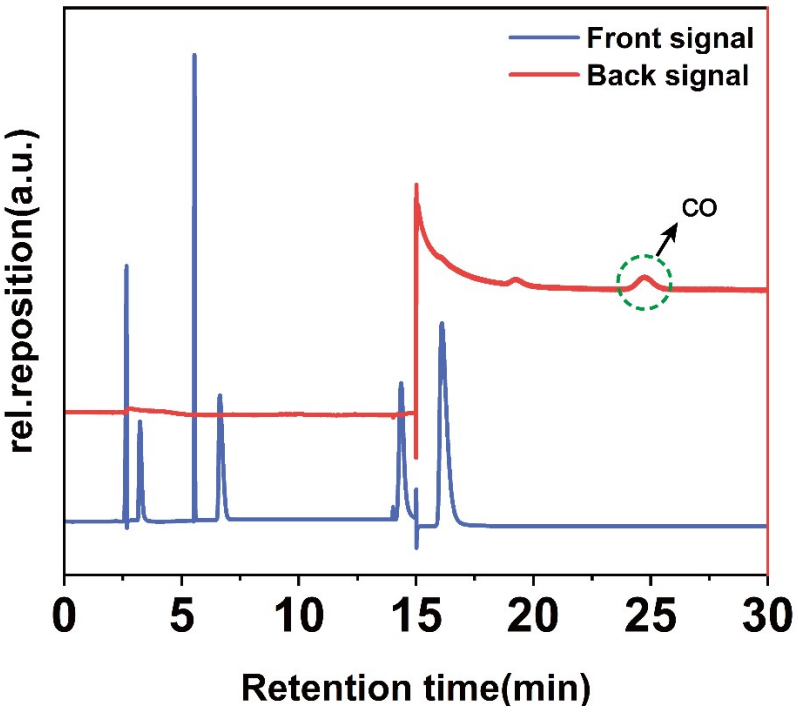

Figure S7. Gas chromatography dual - channel detection chromatogram of gases after 2 hours of reaction.

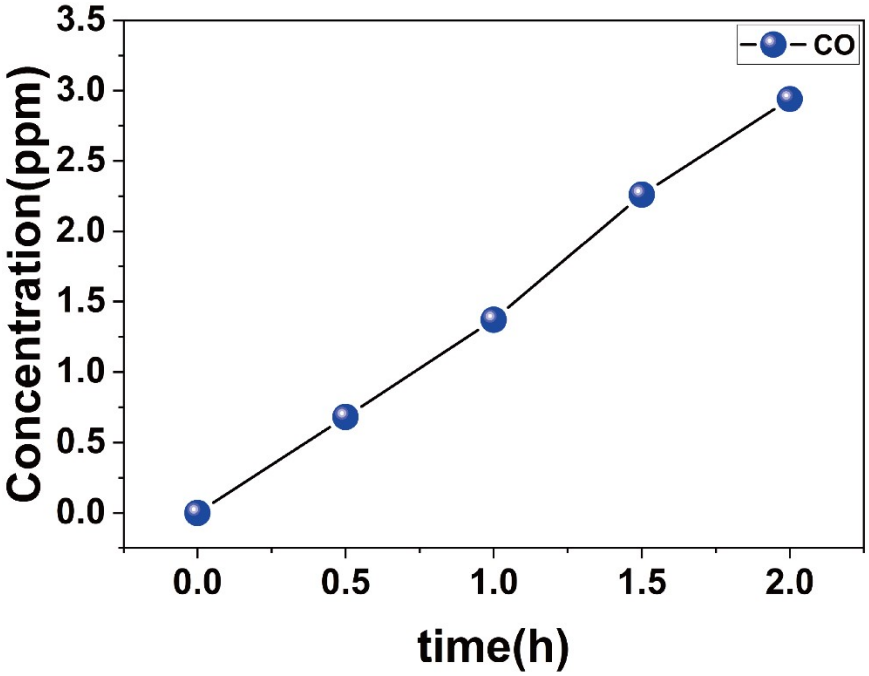

Figure S8. Temporal evolution of carbon monoxide concentration measured by gas chromatography

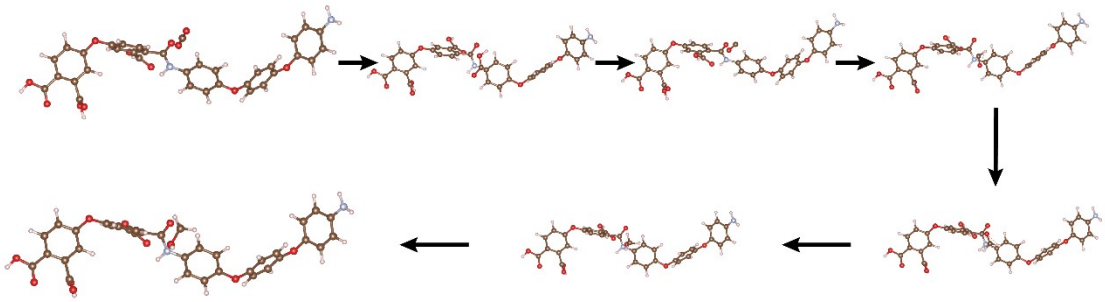

Figure S9. Molecular conformation evolution diagram of polyimide obtained by DFT calculations.

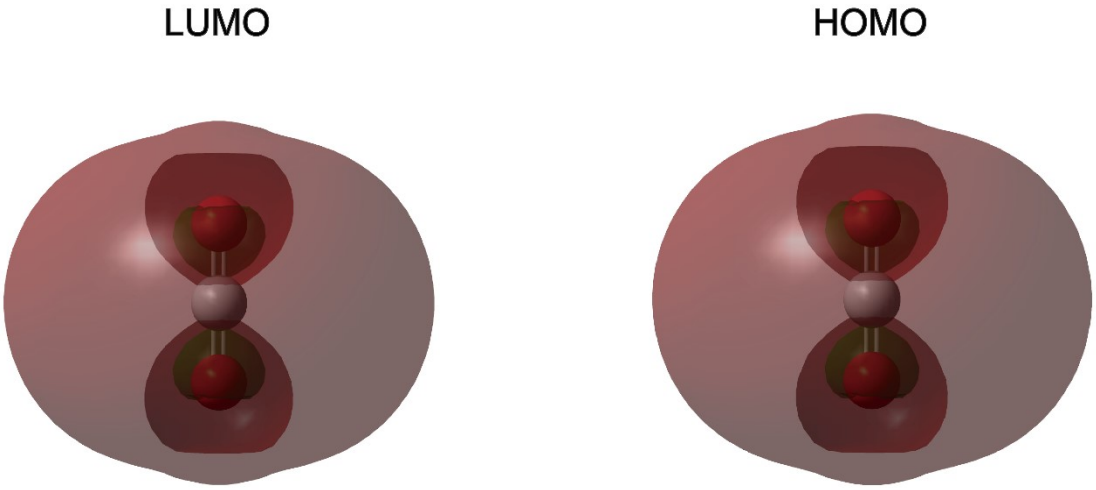

Figure S10. Orbital diagram of LUMO and HOMO for the carbon dioxide molecule obtained by DFT calculations.

Figure S11. The pH of the liquid was measured after 2 h of ultrasonic contact catalysis.

Supporting Tables

Table S1. Comparison of the present work with recent advances in electrocatalytic CO_2 reduction.[1-6]

Reactants	Products	Productivity	Selectivity	Authors
CO_2	Amorphous carbon	11.4wt%	/	**Luo et al.**[1]
CO_2	CO	0.02244 μmol/h	96.24%	**Wang et al.**[2]
CO_2	C_2H_4	4.7 μmol/m^3	/	**Wang et al.**[3]
CO_2	CH_3OH	59.4 nmol/h	97%	**Wang et al.**[4]
CO_2	CH_3OH	13 nmol/h	>90%	**Wang et al.**[5]
CO_2	H_2+CO	11.82 μmol/h(H_2) 9.59 μmol/h(CO)	55%	**Nguyen et al.**[6]
CO_2	CH_3OH	68.4 μmol/h	93.6%	**This work**

Supporting References

1. Luo, H.; Gao, S.; Yang, H.; Wang, G.; Shen, J.; Liu, Q.; Liu, J.; Li, Q.; Duan, L.; Yang, P., Contact-Electrocatalytic CO 2 Reduction via Solid–Liquid–Gas Interfaces Involving Liquid Metals. *ACS Sustainable Chemistry & Engineering* **2026**.
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4. Wang, N.; Feng, H.; Yang, J.; Hong, J.; Ye, E.; Jiang, W.; Zhang, Y.-W.; Wang, Z.; Jun, X.; Li, Z., Boosted contact-electro-catalytic CO2 to methanol enabled by a built-in electric field design. *Nano Energy* **2026,** *152*, 111883.
5. Wang, N.; Feng, H.; Yang, J.; Zheng, J.; Zhang, Y. W.; Hadjichristidis, N.; Li, Z., In Situ High Selectivity Contact-Electroreduction of CO2 to Methanol Using an Imine-Mediated Metal-Free Vitrimer Catalyst. *Angewandte Chemie International Edition* **2025,** *64*.
6. Nguyen, H. P.; Nguyen, N.; Tran, D.; Duong, T. H.; Nguyen, T. T.; Bowen, C. R.; Li, Z. H.; Arafa, M.; Dunn, S.; Pham, T. T., Highly Efficient Sono-Contact-Electrocatalysis Enabled by Fine-Scale and Ultrasonically Generated Polytetrafluoroethylene Particles. *Advanced Energy and Sustainability Research* **2026,** *7*